DOCUMENT RESUME

ED 452 998 PS 029 509

AUTHOR Marr, Deborah; Windsor, Mary-Margaret; Cermak, Sharon
TITLE Handwriting Readiness: Locatives and Visuomotor Skills in the Kindergarten Year.
PUB DATE 2001-00-00
NOTE 17p.; In: Early Childhood Research & Practice: An Internet Journal on the Development, Care, and Education of Young Children, 2001; see PS 029 507.
PUB TYPE Journal Articles (080)
EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Cognitive Development; *Handwriting; *Kindergarten Children; Motor Development; Primary Education; Skill Development; Spatial Ability; *Writing Readiness; Writing Skills
IDENTIFIERS *Graphomotor Skills; *Locatives; Visual Motor Functioning

ABSTRACT

Handwriting is an integral part of every child's school experience. In order to provide the best program to children both with and without handwriting problems, elementary educators need to understand the factors underlying the skill of handwriting. This study investigated the relationship between the cognitive understanding of locatives (e.g., words used for spatial and temporal concepts, such as "up" or "next to") and the graphomotor task of shape and letter copying in typically developing kindergarten children. Additionally, changes in those skills during the kindergarten year were examined. The Developmental Test of Visual-Motor Integration, the Boehm Test of Basic Concepts, and the Scale of Children's Readiness In PrinTing were administered to a sample of 138 children during the first and second half of their kindergarten year. The findings showed a significant increase in performance on all three measures from time one to time two. The relationships among the three tests varied. A moderate positive relationship between the visuomotor and handwriting test was found. This result supports previous findings that link visuomotor skills to handwriting. All other relationships were low. This study adds to a growing body of knowledge about the prerequisite skills needed for handwriting. (Contains 51 references.) (Author/HTH)

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ECRP Early Childhood Research & Practice

Spring 2001
Volume 3
Number 1

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Handwriting Readiness: Locatives and Visuomotor Skills in the Kindergarten Year

Deborah Marr, Utica College of Syracuse University; **Mary-Margaret Windsor,** Towson University; & **Sharon Cermak,** Boston University

Abstract

Handwriting is an integral part of every child's school experience. In order to provide the best program to children both with and without handwriting problems, elementary educators need to understand the factors underlying the skill of handwriting. This study investigated the relationship between the cognitive understanding of locatives (e.g., words used for spatial and temporal concepts such as "up" or "next to") and the graphomotor task of shape and letter copying in typically developing kindergarten children. Additionally, changes in those skills during the kindergarten year were examined. The Developmental Test of Visual-Motor Integration, the Boehm Test of Basic Concepts, and the Scale of Children's Readiness In PrinTing were administered to a sample of 138 children during the first and second half of their kindergarten year. The findings showed a significant increase in performance on all three measures from time one to time two. The relationships among the three tests varied. A moderate positive relationship between the visuomotor and handwriting test was found. This result supports previous findings that link visuomotor skills to handwriting. All other relationships were low. This study adds to a growing body of knowledge about the prerequisite skills needed for handwriting.

Introduction

Handwriting is an integral part of every child's school experience. Thirty to 60% of the elementary school child's class time is spent in fine motor/writing activities, with writing as the predominant task (McHale & Cermak, 1992). Some students have difficulty in the production of legible handwriting. Factors that contribute to illegible writing are incorrect letter formations or reversals, inconsistent size and height of letters, variable slant and poor alignment, and irregular spacing between words and letters (Alston & Taylor 1987; Tseng & Cermak, 1991; Ziviani & Elkins, 1984). Programs to address handwriting problems have been varied and include visual perception and visuomotor and letter formation training (Oliver, 1990; Lockhart & Law, 1994; Peterson, 1999). In order to provide the best program to children both with and without handwriting

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problems, it is necessary for elementary educators to understand the factors underlying the skill of handwriting.

Issues Related to Handwriting

Many studies have addressed the underlying factors related to handwriting. These factors can be categorized into external and internal factors. Examples of external factors are instructional procedures and materials used during writing (Alston, 1985; Carlson & Cunningham, 1990; Pasternicki, 1987; Rubin & Henderson, 1982; Zaner-Bloser, 1994; Ziviani, 1987). Internal factors are abilities found within the student: visuomotor skills, visual perception, motor planning (i.e., the ability to plan new motor behavior), in-hand manipulation, and kinesthetic awareness (Berninger & Rutberg, 1992; Case-Smith & Pehoski, 1992; Laszlo & Bairstow, 1984; Maeland, 1992; Schneck, 1991; Tseng, 1991; Tseng & Murray, 1994; Weil & Amundson, 1994; Ziviani, Hayes, & Chant, 1990; Ziviani, 1995). The internal factor of cognition and its relationship to handwriting has not been extensively studied. Several authors (Brown & Donnenwirth, 1990; Chu, 1997; Exner, 1990; Exner & Henderson, 1995; Moore & Law, 1990; Naka, 1998) have discussed the link between various aspects of cognition—particularly attention, memory, and language—and handwriting skill. It is suggested that success in handwriting can be optimized when the internal factors are at age-appropriate levels, making the student ready to benefit from classroom instruction.

Writing Readiness

Readiness is a term that describes foundation skills present before the child learns a new task (Slavin, Karweit, & Wasik, 1994). Sovik (1975) described writing readiness as having the needed characteristics to "profit satisfactorily from the instruction given in the teaching of handwriting at different stages through elementary school" (p. 54). Writing readiness skills have been further specified by several authors. Lamme (1979) outlined six prerequisites for handwriting: small muscle development, eye-hand coordination, utensil or tool manipulation, basic stroke formation, alphabet letter recognition, and orientation to written language. Benbow, Hanft, and Marsh (1992) listed four prerequisite areas: dominant hand use, midline crossing with the dominant hand, proper posture and pencil grip, and ability to copy the first nine shapes of the Developmental Test of Visual-Motor Integration (Beery & Buktenica, 1989). Other authors have identified kinesthetic readiness as an important precursor to handwriting instruction (Benbow, 1995; Laszlo & Bairstow, 1985; Levine, 1998). A foundation in kinesthesia allows reception of ongoing error information from handwriting efforts: this necessary information is stored in memory to be recalled when the movement is repeated. While younger children may substitute visual for kinesthetic feedback in the early elementary years, the switch to kinesthetic feedback should be made eventually to produce faster handwriting. If this switch is not made, the increasing demand for writing production in the later elementary years may result in academic productivity problems.

Cognitive readiness could affect handwriting performance. Several authors have suggested that a certain level of cognitive/language ability needs to exist before handwriting performance is optimal. Exner and Henderson (1995) stated that cognitive skills including attention, memory, perception, and language affect the learning of motor

skills, but that the role of cognition diminishes once the skill is learned and skill refinement is in progress. Chu (1997) recommended evaluation of the cognitive components of attention, memory, language comprehension, and reasoning when a child has handwriting difficulties. Sandler et al. (1992) found that three of the four patterns of writing disorders identified in 9- to15-year-olds had links to either cognitive or visual-perceptual function. These included expressive language, rapid naming, picture naming, attention, and memory. While many authors recognize that cognition/language plays an important role in handwriting, the question of what constitutes critical cognitive readiness is not clearly answered.

The Kindergarten Year

Formal handwriting instruction may begin as early as the kindergarten year (Zaner-Bloser, 1994). The verbal directions used in handwriting instruction assume children understand spatial and temporal concepts. Terms such as "on top of the line," "above the line," or "between the lines" are used in handwriting curriculum (Benbow, 1995). An ability to understand these terms is acquired in a developmental sequence. Johnston (1988) summarized 19 studies on the acquisition of spatial location terms. The age at which the average child begins to understand the locative "in" is 2 years. Additional locatives are learned as the child increases in age, with the most challenging locative, "back/front," attained by the average child at 4 years 8 months. Examining children's understanding of spatial and temporal concepts would influence handwriting curriculum as well as intervention strategies used in the classroom.

While many studies examine handwriting of the older child (second grade and higher), fewer have researched the early years of beginning writing. Tan-Lin (1981), Tolchinsky-Landsman and Levin (1985), and Gombert and Fayol (1992) looked at handwriting samples of children in the 3- to 6-year-old range. These studies found a developmental sequence beginning in the younger ages with drawing and scribbling, and concluding in the older age groups with an ability to write legible letters. Tan-Lin (1981) found that at least one-third of 4- to 6-year-olds could print up to five simple words from memory. Common words written by this age group were MOM, DAD, DOG, CAT, and STOP.

Tan-Lin (1981) identified the quality changes in handwriting in 4- to 6-year-olds. She noted that such factors as size, quantity, proportion, and spacing improve with age. Additional studies of older children have examined size and proportion. Smits-Engelsman and Van Galen (1997) found that dysgraphic children (i.e., children with writing deficits) 7 to 11 years old showed more variability in letter size than nondysgraphic children. Windsor (1995), studying handwriting legibility, developed the concept of "letter form width." This composite measure determined from letter sizes allows comparison of relative size/form of letters between handwriting samples. She found that 8- to 11-year-old boys with attention deficit/hyperactivity disorder (ADHD) wrote larger letters than typical boys of the same age. Hamstra-Bletz and Blote (1993), in a longitudinal study of dysgraphic handwriting from grades two to six, found that inconsistent letter size was a common feature in dysgraphic writing.

Weil and Amundson (1994) examined the relationship between the kindergartner's ability to copy letter forms and geometric shapes. They analyzed performance on the

Developmental Test of Visual-Motor Integration (VMI) and the Scale of Children's Readiness In PrinTing (SCRIPT). A Pearson product-moment correlation coefficient revealed a moderate correlation ($r = .47$, $p < .001$). Students at the end of the first semester of kindergarten were, on average, able to copy 78% of the letters presented. Additionally, 88% were able to copy the first nine forms of the VMI. They concluded from the results "...that most children in kindergarten will be ready for beginning handwriting instruction during the latter half of the kindergarten school year" (Weil & Amundson, 1994, p. 987).

Although some aspects of handwriting in the kindergartner have been investigated, the relationship between the cognitive ability of understanding spatial and temporal concepts and handwriting has not been explored. Specifically, this study investigated the relationship between the cognitive understanding of spatial and temporal locatives and graphomotor production, including shape and letter copying, at two points in the kindergarten year. It was hypothesized that there is a positive, moderate correlation between the scores on the Boehm Test of Basic Concepts (Boehm, 1986), the Developmental Test of Visual-Motor Integration (Beery, 1997), and the Scale of Children's Readiness In PrinTing (Amundson & Weil, 1996) for both test sessions. Further, it was hypothesized that despite the fact that formal handwriting instruction does not occur in kindergarten, scores on all measures will increase from the first half of the year to the second half of the year.

Method

Participants

The participants for this study included 61 boys and 77 girls, with 120 right-handed students and 18 left-handed students. Ages at the first session ranged from 4 years 11 months to 6 years 7 months, with a mean age of 5 years 7 months (standard deviation 3.9 months). This convenience sample of typically developing children represents the majority of the kindergarten students in a middle-income, suburban community in upstate New York. A student was considered typically developing if there was no Individualized Education Plan (IEP) in place, he or she had not been retained in kindergarten, and he or she had English as the primary language. Six percent of the district's students are in families below the poverty level, with 10% using the free/reduced lunch program. Racial distribution of the participants was 93% white, 2% black, 1% Asian, and 4% other.

The teachers sent consent forms to all 180 registered kindergarten students. There were 177 consent forms returned. Eight students were on IEPs and were not included in the study. Additionally, 31 children were not included due to absence on one of the test dates or incomplete tests.

Instruments

The Developmental Test of Visual-Motor Integration (VMI) (Beery, 1997) is a widely used test of visuomotor skills. The student copies a series of shapes in a test booklet, and the graphic responses are scored using the criterion listed in the manual. Each shape is

awarded either a 1 for passing or a 0 for failing. Scoring is discontinued after the student has earned three consecutive 0s. The maximum score possible is 18. This test was recently revised in 1997. Test-retest reliability is reported as .87, and inter-scorer reliability is reported as .94. Additional detailed information on the reliability and validity is cited in the test manual. Inter-coder agreement was examined for this study using a Pearson correlation. Resulting correlation between the first author and an experienced occupational therapist on a set of 10 student tests was .97.

The Boehm Test of Basic Concepts (BTBC) (Boehm, 1986) is a standardized, norm-referenced test designed to assess children's mastery of basic concepts. Each child has a booklet with pages containing several rows of three pictures. The examiner cues the child to a row and reads a question, and the child responds by marking the correct picture within the row. The test consists of 50 questions. Examples include "Mark the dog that is at the end of the line" and "Mark the animal that is at the bottom." Administration can be done in a group or individually. For a kindergarten sample, split-half reliability is reported to be .81, and test-retest reliability for tests given one week apart was .85. More detailed information on reliability and validity is given in the test manual (Boehm, 1986). For the present study, inter-coder agreement was established using a Pearson correlation. Correlation results between the first author and an occupational therapy research assistant on a set of 10 tests was found to be .97.

The Scale of Children's Readiness In PrinTing (SCRIPT) is a letter form copying research test developed by Weil (Weil & Amundson, 1994). The test booklet consists of five pages with a maximum of eight letters per page using the Zaner-Bloser manuscript alphabet. All 26 lowercase letters are included, as are the following eight uppercase letters: A, K, M, N, V, W, Y, Z. In total, the student copies 34 letters. The student sees the stimulus letter printed in the center of a square and is asked to copy the letter in the blank square space located directly below the stimulus letter. The test developer provided scoring criteria. Point-by-point reliability was reported at 90% to 100%. This level of reliability was not achieved during the initial scoring for the present study. Therefore, the decision was made to investigate reliability of scoring for this test. More refined parameters, which included criterion from the Test of Copied and Dictated Writing, were developed (see Figure 1) (Windsor, 1995). Similar to the original scoring of the SCRIPT, each letter was scored as pass/fail, but unlike the SCRIPT, each letter was judged by more specifically defined criteria, which allowed for more discriminate judging of each letter. Using the refined parameters and a Pearson correlation, an inter-coder agreement on a set of 10 tests was found to be .95 between the first and third author.

1. The letter is quickly and easily recognized as itself and no other symbol using the "peek hole" method; no gross errors in proportion are present. Case (upper or lower) is correct.

2. The letter has no missing parts and no extra parts. This includes the need to have the "stick" on a lower case "n."

3. No lines extend beyond the intersection by more than 2 mm.

4. Baselines and toplines must be parallel to the horizontal boundary lines of the blank stimulus box within 3 mm. Top lines and bottom boundary lines are not used for the letters "a," "b," "d," "q," "g," "r," "p," and the bottom of "u."

5. Upstrokes and downstrokes must be parallel to the vertical boundaries within 3 mm. The capital letter "M" and the dots on "i" and "j" are not included in this criterion. The side points of "z," "s," "x," "k," "e," and "c" must fall within a 3-mm space of each other, which is perpendicular to the horizontal boundaries.

6. Letter forms must be closed correctly with no more than a 2-mm gap. For "k," this means the intersection of the two angled lines can be no more than 2 mm apart.

7. Curved lines must be curved, and straight lines must be able to fit within a 2-mm space. These criteria include any extension lines that may be present.

8. Angles must be present.

9. There is no rotation of more than 45 degrees in any part of the letter; no reversals are present.

10. Each side of the horizontal line in "t" and "f" must be within 2-mm length of the other; the bottom portion of the vertical line of the "t" must be at least 2 mm longer then the top side.

11. Oblique lines cannot be perpendicular to the outer boundary lines (e.g., "v," "w," "y").

Figure 1. Criteria for scoring the Scale of Children's Readiness In PrinTing (SCRIPT).

Letter and word size may indicate maturity of a student's writing. Various authors have noted that large and variable-sized letters are markers of poor handwriting (Alston & Taylor, 1987; Hamstra-Bletz & Blote, 1993; Tseng & Cermak, 1991; Windsor, 1995; Ziviani & Elkins, 1984). An index of letter/word size called Word Form Width (WFW) was developed for this study. The students were asked to write five words from dictation on unlined paper. Words (MOM, DAD, DOG, CAT, and STOP) were chosen from a

study by Tan-Lin (1981) that identified words frequently written by 4- to 6-year-olds. The words were spoken and spelled. The first word produced, MOM, was used to determine Word Form Width. See Figure 2 for measurement criteria. Inter-coder agreement between the first and second author on 10 samples was established at .94 using a Pearson correlation.

1. Measure the word only if it contains all letters, is in a relatively straight line, contains no reversals, is located in the large white space at the bottom of the page, and is generally recognizable.

2. Measure the distance in millimeters at baseline from the far left outer edge of the word to the right outer edge of the word.

3. Round the millimeter to the nearest whole centimeter.

Figure 2. Criteria for scoring Word Form Width.

Procedure

Prior to testing, the teachers were surveyed regarding their teaching experience and training in handwriting instruction. Nine of the ten teachers responded to the survey. The average number of years in teaching was 19.8, with a range of 7 to 30 years. The average number of years teaching kindergarten was 7.6, with a range of 0 to 20 years. None of the teachers reported having any training in handwriting instruction either as undergraduates or in workshops. While a specific handwriting curriculum is not used at the kindergarten level, the average time devoted per week to handwriting instruction in the classroom was 55 minutes, with a range of 40-90 minutes. Teaching techniques included demonstration and verbal cueing for letter formation.

There are 10 full-day kindergarten classes in this district. The participants were tested in their classrooms using group procedures. The first author administered all tests. Test sessions were scheduled in collaboration with the teachers. The sequence of tests was counterbalanced across the classrooms to control for fatigue and order effects. Testing occurred in November (Session 1) and April (Session 2). The tests were given in two separate time periods on the same day. The VMI and SCRIPT were administered in one 15-minute time period. The BTBC was administered in a 30-minute time period. The two time periods were separated by a range of 30 minutes to 3 hours based on the schedule of each class.

The VMI and the BTBC were administered according to standard group procedures from the manual. Before beginning the SCRIPT, students were asked to write the following dictated words on the open space provided on the cover sheet: MOM, DAD, DOG, CAT, STOP. Each word was spoken and spelled.

The directions for the SCRIPT were as follows:

> Please copy the letters you see in the box below each letter. When you are done with one page, go on to the next page until you have done all the

pages. When you are done, please put your pencil down in front of you on the desk.

Results

Directional paired *t*-tests were calculated, and as hypothesized, increased performance on the VMI, SCRIPT, and the BTBC was significant over the course of the kindergarten year (see Table 1). There was no significant change in the scores for Word Form Width.

Table 1

Total Scores for Sessions 1 and 2 on Graphomotor and Locative Measures

		Session 1		Session 2			
Test	*N*	M	SD	M	SD	*t*-Test	Effect Size
VMI	138	12.6	2	14	1.8	7.8*	0.7
SCRIPT	138	15.3	5.7	19.1	5.4	7.7*	0.7
BTBC	138	43.1	4.9	44.6	4.1	4.6*	0.4
WFW	114	6.4	2.9	6.2	2.8	0.6	0.1

Note: VMI = Developmental Test of Visual-Motor Integration; SCRIPT = Scale of Children's Readiness In PrinTing; BTBC = Boehm Test of Basic Concepts; WFW = Word Form Width.
*$p < .05$.

Pearson product-moment correlations were calculated between the VMI, SCRIPT, BTBC, and Word Form Width. For Session 1 (see Table 2), a moderate correlation was found between the SCRIPT and the VMI ($r = .39$), and the SCRIPT and the BTBC ($r = .30$). The remaining correlations were low ($r < .25$). As expected, a negative relationship existed between WFW and the SCRIPT ($r = -.21$) because as children get older, they write more legibly and smaller.

Table 2

Pearson Product-Moment Correlations between Measures for Session 1

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Measure	1	2	3	4
VMI				
SCRIPT	.39*			
BTBC	.25*	.30*		
WFW	.22*	-.21*	.19*	

Note: VMI = Developmental Test of Visual-Motor Integration; SCRIPT = Scale of Children's Readiness In PrinTing; BTBC = Boehm Test of Basic Concepts; WFW = Word Form Width.
*$p < .05$. $N = 138$.

For Session 2 (see Table 3), the relationship between the SCRIPT and the VMI continued to be moderate ($r = .36$). All other correlations were low. The negative relationship between WFW and the SCRIPT was again demonstrated. As in Session 1, the hypothesis of a moderate relationship between the VMI and the SCRIPT was supported. However, a moderate relationship between the SCRIPT and the BTBC was not.

Table 3

Pearson Product-Moment Correlations between Measures for Session 2

Measure	1	2	3	4
VMI				
SCRIPT	.36*			
BTBC	.29*	.19*		
WFW	-.04*	-.22*	-.10*	

Note: VMI = Developmental Test of Visual-Motor Integration; SCRIPT = Scale of Children's Readiness In PrinTing; BTBC = Boehm Test of Basic Concepts; WFW = Word Form Width.
*$p < .05$. $N = 138$.

Discussion

The purposes of this present study were to examine changes in cognitive, visuomotor, and graphomotor skills over time, and to investigate the relationship between the

cognitive understanding of spatial and temporal concepts, visuomotor skills, and graphomotor production in the kindergarten child. Considering the first purpose, three of the four measures demonstrated statistically significant improvements over the course of the kindergarten year. Changes in WFW were not significant. Change would be expected due to maturity and classroom training as skill is improving for this age group. The lack of significant change in WFW scores may reflect the measure used. Children were given a large space on which to write their words. The use of lined paper may have prevented them from using more of the page than they might otherwise have done. Additionally, WFW may not be an appropriate measure of a student's writing maturity for this age group because writing skill may still be variable.

Benbow, Hanft, and Marsh (1992) have suggested that children are ready for handwriting instruction once they can copy the first nine forms of the VMI. Only two subjects received a score of less than 9 on the VMI at Session 1. The SCRIPT scores for these two children were between 1 and 2 standard deviations below the mean. No child received a VMI score of less than 10 at Session 2. The two subjects with low VMI scores at Session 1 had SCRIPT scores of 1 standard deviation below the mean in Session 2. According to Benbow's criteria, all children in this sample were ready for handwriting instruction at Session 2. Weil and Amundson (1994) also concluded that most children would be ready for handwriting instruction in the latter half of their kindergarten year.

Results related to the second purpose indicated that a moderate relationship exists between visuomotor and graphomotor skills. Tseng and Murray (1994), studying children in grades three to five, found correlations consistent with the present study. In their study, a sample of poor handwriters had a correlation of $r = .31$ between handwriting and the VMI, while a sample of good handwriters had a correlation of $r = .33$. Four teachers rating legibility of a copied textbook paragraph measured handwriting. The relationship between graphomotor production and visuomotor skill was not as strong as that seen in some other studies. Weil and Amundson (1994), examining typical children using the same measures and the same age group, found the correlation to be moderate ($r = .47$). Their scoring criteria for the SCRIPT was more lenient than that used in the present study and resulted in a mean score of 26.2 out of 34 in the second half of the kindergarten year, compared with the 19.1 out of 34 in Session 2 of the present study. Maeland (1992) examined the relationship of the VMI with handwriting of 10-year-old students and found a correlation similar to Weil and Amundson (1994) ($r = .43$). Independent judges rating legibility of six dictated sentences on a 7-point scale measured handwriting. The different methods used to measure handwriting may contribute to the range of correlations seen.

The relationship between cognitive skills and handwriting has not been extensively studied. However, several authors have stated the importance of cognition in any skilled motor task (Brown & Donnenwirth, 1990; Chu, 1997; Exner, 1990; Exner & Henderson, 1995; Henderson & Pehoski, 1995; Meulenbroek & Van Galen, 1990; Sandler et al., 1992). Understanding spatial and temporal concepts had a low relationship to visuomotor or graphomotor skills in the present study. Because this sample primarily included typically developing, middle and upper socioeconomic children, spatial and temporal concepts needed for writing may already be understood. The BTBC manual indicates that 98% of kindergarten children understand the word "top," 90% understand the word "between," and 85% understand the word "above" (Boehm, 1986). Because

these words are used during handwriting instruction, the variations in graphomotor production may be due to factors not related to these measured concepts. This finding may not be the case for children from different socioeconomic backgrounds or cultures.

Implications for Practice

Educators are concerned about a young student's readiness for handwriting instruction. The results of this study add to the growing conclusion that typical students in the latter half of kindergarten have the foundation skills needed to begin formal handwriting instruction. Kindergarten teachers should consider available curricula that offer beginning handwriting training and are motivational for this age group.

Early identification of children with the potential for handwriting problems is another concern for the kindergarten teacher. The results of the present study point out an area that may assist in early identification: the relationship between visuomotor skills and handwriting. Evaluating visuomotor skills may help pinpoint children who need close monitoring or specific interventions to prevent the development of handwriting problems. Future research needs to investigate whether training in visuomotor skills will increase handwriting performance.

Limitations

The first limitation of the present study relates to the use of group administration of the measures. Although group administration of the measures is described in the manuals, the teachers felt that many of the students rushed to keep pace with their classmates. It was also noted that some children looked to their peers for correct answers or models of writing despite the efforts of the examiner to discourage such behavior. Classroom teachers reported feeling their students were capable of higher performance if the tests had been given individually.

The subjects used for this study were homogeneous, generally from a higher socioeconomic level, and had no identified disabilities. These characteristics may have resulted in less variability in scores and less representation of kindergarten children as a whole and may limit generalizability of the results to children with low socioeconomic status or atypical abilities.

Implications for Future Research

The present study examined typically developing children and has supported the importance of visuomotor skills in handwriting for the kindergarten child. Examining this relationship within populations at risk for handwriting problems would be valuable. If the relationship is stronger with these children, handwriting teaching strategies using locative concepts may need to be adapted.

Acknowledgments

This study was supported in part by a grant to Sargent College Health and Rehabilitation Sciences, Boston University, from the U.S. Department of Health and Human Services, Health Resources and Services Administration, Maternal and Child Health Bureau (MCJ-000-901) and MCH grant #MCJ 08941301. This article was written in partial fulfillment of the first author's requirements for the degree of Doctor of Science in Therapeutic Studies at Boston University. The authors would like to thank the New Hartford School District for their help and cooperation in this study.

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Author Information

Deborah Marr, MS, OTR/L, is an assistant professor of occupational therapy at Utica College of Syracuse University focusing on courses related to pediatrics and research. She also is a doctoral student at Boston University's Department of Occupational Therapy. Her research interests include the fine motor and sensory processing skills of preschool and early elementary children, and current clinical work involves consultation to the Head Start program.

Deborah Marr

Utica College of Syracuse University
1600 Burrstone Rd.
Utica, NY 13502
Telephone: 315-792-3101
Email: dmarr@utica.ucsu.edu

Mary-Margaret Windsor is a former clinical assistant professor, Department of Occupational Therapy at Boston University. She received a BSOT (1968) and an MEd (1976) from the University of New Hampshire. She earned a Doctor of Science Degree in Therapeutic Studies (1995) from Boston University. Currently she is an instructor in sensory integration for Western Psychological Services, a visiting assistant professor at Towson University, Department of Occupational Therapy and Occupational Science, and is involved in humanitarian work and occupational therapy practice internationally.

Sharon A. Cermak, EdD, OTR/L, FAOTA, is professor of occupational therapy at Boston University and project director of an occupational therapy doctoral leadership training grant from the Maternal and Child Health Bureau, Health Resources and Services Administration. Dr. Cermak is director of occupational therapy training at the interdisciplinary Leadership in Education in Neurodevelopmental Disabilities (LEND) program at Children's Hospital, Boston. She is a former Fulbright scholar and a recipient of the R.K. Gray award. Dr. Cermak's research includes examination of (1) motor planning deficits in children, and (2) sensory processing, emotional regulation, and development in post-institutionalized children.

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